Rat River Dolly Varden

Background

Char west of the Mackenzie River were originally thought to represent a distinct form (western Arctic-Bering Sea) of Arctic char (Salvelinus alpinus) (McPhail 1961, McCart 1980). Re-evaluation of taxonomic identity using morphological and genetic criteria confirmed that the char found in high gradient rivers west of the Mackenzie River are in fact Dolly Varden (Salvelinus malma) (Reist et al. 1997). Arctic char typically occur in river systems to the east of the Mackenzie River drainage (e.g., Hornaday River, Kuujjua River).

The Rat River, located 90 km south-west of Inuvik, NT, flows east from headwaters in the Richardson Mountains, and drains into the Husky Channel of the Mackenzie River (Fig. 1). The northern form of Dolly Varden, described by Reist et al. (1997), inhabit this system. Spawning and over-wintering areas for the Dolly Varden are located in spring-fed reaches of Fish Creek, a tributary of the upper Rat River.

The Gwich'in word for Dolly Varden is "Dhik'ii" (GRRB 1997), while the Inuvialuit word is "qalukpik" (Lowe 1984). The common name "char" is still used locally and in community-based documents such as the "Rat River Char Fishing Plan" (Aklavik RRC et al. 2000) and the community-based "Rat River Char Monitoring" study.

This stock was assessed in support of the Rat River Char Fishing Plan (Aklavik RRC et al. 2000), which was prepared with the assistance of the Department of Fisheries and Oceans (DFO), the Gwich'in Renewable Resource Board (GRRB), and the Fisheries Joint Management Committee (FJMC).

Fig. 1. The lower Mackenzie River and tributaries, including the Rat River.

Summary

- Anadromous Dolly Varden, known locally as "char", inhabit the Rat River and its tributaries.
- Rat River Dolly Varden represent one of six known populations of the northern form of Dolly Varden in Canada.
- The Dolly Varden that inhabit this system are genetically distinct and show a higher degree of genetic diversity than populations in neighbouring systems.
- Harvesters from two adjacent land claim groups, the Gwich'in and the Inuvialuit, harvest Dolly Varden from the Rat River stock.
- Communities of Aklavik and Fort McPherson developed and implemented their "Rat River Char Fishing Plan" in 1995.
- The Plan currently recommends that the total take of Dolly Varden in the food

fishery not exceed 2000 fish per year, and specifies the number of nets which may be used per household, their size and depth restrictions.

- Compliance with the Plan has been improving over the past years, with the community harvest during 1999 and 2000 being in full compliance with the recommendations of the Plan.
- The fishery has been monitored through a community-based sampling program since 1989. This program was expanded from one site to five sites in 1995 and continues to the present day.
- The average annual harvest between 1990-1999 is equivalent to 13.0% of the 1998 stock size estimate, and 17.7% of the 1996 estimate.
- There has been no decline in the size of the Rat River Dolly Varden stock, as estimated over the last decade.
- During the monitoring program from 1989-2000, CPUE (catch-per-unit-effort), length- and age-frequency distributions, sex and maturity ratios of Rat River Dolly Varden have remained relatively unchanged.
- The stock appears to be stable and in no immediate danger under the current harvest strategy. The outlook for the stock is favourable, given careful annual monitoring of harvest, periodic independent experimental estimation of the size and composition of the stock, and continued compliance with the community-based fishing Plan.

Species Biology

Dolly Varden are closely related to the Arctic char, lake trout (*Salvelinus namaycush*) and brook trout (*Salvelinus fontinalis*). Externally, Dolly Varden can be distinguished from anadromous Arctic char because they have a more fusiform body shape, pupil-sized light spots on the body with blue halos (as opposed to trout and salmon which usually have black spots or speckles), and generally, a less-forked tail fin. The sea-run form of Dolly Varden are silvery with an olive-green to brown colour on the dorsal surface.

In the Canadian Arctic, Dolly Varden occur in several rivers to the west of the Mackenzie River, including the Yukon North Slope during the summer months. The Vittrekwa River (upper Peel River drainage), Big Fish River, Babbage River, Firth River and the Rat River all support separate genetic stocks of this species (Fig. 1).

Many Dolly Varden stocks exhibit both an anadromous (sea-run) and a residual, non-migratory (solely freshwater) form (McCart 1980). The former is the most commonly observed. They reside in their headwater streams for approximately three years, before making their first migration to the Beaufort Sea to feed in summer. They return in the fall to the freshwater riverine environment for over-wintering. At this stage they are approximately 120 mm in length, and are called smolts.

They continue to make summer and fall migrations to and from the sea for the remainder of their lives. Spawning in the Rat River drainage occurs in the Fish Creek tributary from mid-August through to early October.

The residual form is comprised almost exclusively of males, which reside in the headwater streams for their entire lives. Although the residual form is common in the neighbouring Dolly Varden systems, they have yet to be observed in the Rat River or it's tributaries (J. Reist, S. Sandstrom, pers. comm.). They mature at a smaller size and younger age than their sea-run counterparts, and "sneak" into the redds to spawn with the anadromous pairs.

Sea-run males and females from North Slope populations begin to mature at age 4 and 450 mm and 355 mm respectively, although most mature at an age of 5-6 years, after having spent two or three summers feeding at sea.

Upon reaching maturity, they appear to spawn every second year, although there is evidence that a proportion (e.g., 25% in 1998) of them are capable of spawning in consecutive years (L. Harwood, unpubl. data). This is likely variable from year to year depending on individual condition, prevailing environmental conditions and the age of the fish (Dutil 1986), and is similar to the situtation found with Arctic char. Few Rat River Dolly Varden live past eight years of age, and most do not spawn every year. Similar to Atlantic salmon (*Salmo salar*), a proportion of the Dolly Varden live to spawn a second time and a small number may live long enough to spawn more than twice.

The Dolly Varden is an opportunistic predator in nearshore lagoon and coastal marine waters, feeding mainly on small fishes and benthic organisms. Community fishermen from Aklavik and Fort McPherson found that aquatic insect remains were the most common food items in the stomachs of fish caught returning from sea (J. Carmichael, pers. comm.). During the upstream migration, and during the spawning and over-wintering period, sea-run Dolly Varden feed very little (S. Sandstrom, pers. comm.).

Description of Habitat

The Rat River straddles the Yukon-Northwest Territories border, and flows from headwaters in the Richardson Mountains along a 130 km (80 miles) course, entering the Husky Channel of the Mackenzie River 35 km (22 miles) north-west of Fort McPherson, NT. Trees are confined to the valleys and lower slopes, and the rest of the basin area is covered by tundra vegetation. The bedrock is mainly sandstone, with some limestone in the northern sections. A headwater tributary, Fish Creek, has many deep pools and is fed by one or more perennial groundwater springs. Water temperatures at the spring discharge sites are in the 4-5 °C range.

The limiting factor for Dolly Varden in the Western Arctic is thought to be the availability of accessible spawning and over-wintering habitat. The high gradient rivers in this area freeze completely to the bottom over much of their length. The exception to this is where groundwater springs discharge, producing sections of the stream that do not freeze to the bottom in winter. This in turn provides over-wintering and spawning habitat (known locally as "fish holes") for the Dolly Varden. Downstream of the discharge area, a large field of layered ice (aufeis) forms as the water becomes cooler, dissipates and finally freezes. During the summer months, most or all of the ice field melts, revealing shallow flows through a braided, gravel plain which is used by the current year non-spawners in fall before ascending to the over-wintering site (Sandstrom *et al.* 2001).

Spawning and over-wintering sites are relatively well known and recent studies have documented that the physical characteristics of similar "fish holes" change over time as sodium, water and silt levels fluctuate (Clark *et al.* 2001).

Specific rearing areas for juvenile Dolly Varden are unknown but, based on knowledge from other similar systems, are most likely located in the spring-fed channels and within the braided area of Fish Creek. They may also make use of habitat in upper reaches of the Rat River mainstem. Any juveniles that disperse downstream of the spring-fed areas must return to them to

over-winter. It may be possible that deeper pools along the main river course could offer over-wintering opportunities, but this has not been documented.

The Rat River basin is utilized either permanently or seasonally by at least 13 other species of fish (Jessop *et al.* 1973). At the spawning and over-wintering site, the most common species next to Dolly Varden is the Arctic grayling (*Thymallus arcticus*). The slimy sculpin (*Cottus cognatus*) is also prevalent.

In the lower reaches of the Rat River, broad whitefish (*Coregonus nasus*), round whitefish (*Prosopium cylindraceum*), northern pike (*Esox lucius*), burbot (*Lota lota*), longnose sucker (*Catostomus catostomus*), inconnu (*Stenodus leucichthys*) and Arctic cisco (*Coregonus autumnalis*) are found during spring, summer and fall.

Burbot and northern pike likely contribute to the natural mortality of sea-run Dolly Varden in the lower reaches of the Rat River and in the Mackenzie River channels and estuary. Predation by sculpins likely contributes to mortality of eggs and juveniles at the nursery and rearing areas in Fish Creek. The presence of fresh seal scars and lamprey wounds on returning sea-run migrants indicate that both these predators also contribute to mortality of sea-run individuals. In addition, wolves, grizzly bears, mink and golden eagles have been observed to feed on all life history stages of Dolly Varden at the spawning and over-wintering site (S. Sandstrom, pers. comm.).

The Fishery

During the summer months, Rat River Dolly Varden are caught along the Beaufort Sea coast, mainly at whaling and fishing camps located along the Yukon coast and at Shingle Point (Fig. 1). Tagging programs have shown that the coastal fisheries harvest Dolly Varden from a mixture of stocks, including those from the Babbage, Firth, Big Fish, and Rat rivers (Fig. 1). The Vittrekwa River stock and some Alaskan stocks may also represent a small proportion of the Dolly Varden harvested at these locations.

Once the Rat River Dolly Varden begin their return migration from the sea, usually between late August and mid-September, they encounter fishermen's nets at a number of locations along the way (Fig. 2). The subsistence harvest usually takes place for 3-4 weeks each year. Floating monofilament gillnets, with mesh sizes of 102 mm (4") and 114 mm (4½"), usually 25 m in length and 30 meshes deep, are currently the most commonly used. Smaller mesh nets (e.g., 89mm or 3½") were used prior to 1998 along with the 102 mm and 114 mm nets, but their use has largely been discontinued since the community fishing Plan was put into place (Aklavik RRC *et al.* 2000).

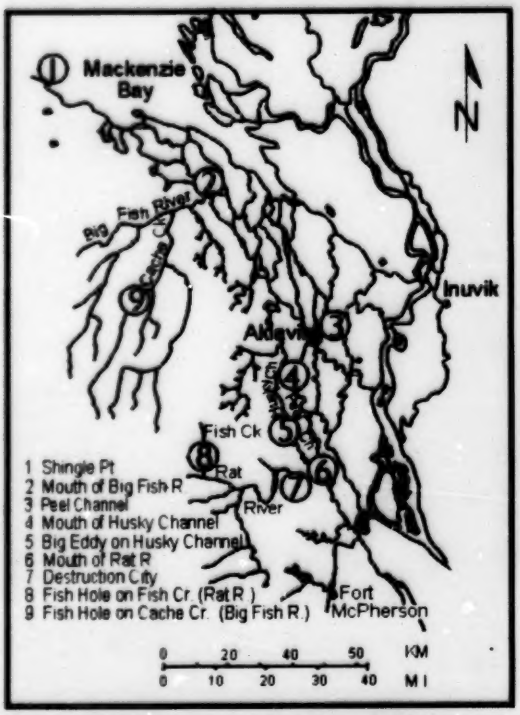

Fig. 2. Fishing sites for Rat River Dolly Varden and spawning and overwintering sites for Rat River and Big Fish River Dolly Varden.

There is apparently no fishing for Dolly Varden at the over-wintering site in Fish Creek, a tributary of the Rat River, at the present time. This practice apparently has not taken place since the mid-1980s (J. Francis, J. Carmichael, pers. comm.).

Table 1. Estimated harvest of Rat River Dolly Varden, 1972-2000.

Year	Number of Fish				
	Inuv. at AK [1,4]	50% Inuv. at SP [1,4]	Gwich'in [2,3]	Unspec. origin [5,6]	Total est.
1972				6500	6500
1973				2600	2600
1975				2100	2100
1980				1545	1545
1986		50		1050	1100
1987		125		3000	3125
1988		74		1607	1681
1989	132	53	1814		1999
1990	60	107	884		1051
1991	20	3	353		376
1992	250	9	775		1034
1993	381	60	968		1409
1994	842	17	1296		2155
1995	377	32	1115		1524
1996	547	403	1970		2920
1997	643	62	2688		3393
1998	255	386	3119		3760
1999	225	125	1561		1911
2000	8	0	1485		1493

AK= Aklavik; SP = Shingle Point; Inuv= Inuvialuit

[1] Inuvialuit Harvest Study, unpublished data, for all years listed except 1999

[2] Inuvialuit Harvest Study, unpublished data, for the years 1986-1994

[3] Gwich'in Harvest Study (MacDonald 1998a,b) and Rat River Monitoring Study (Harwood 2001) for 1995-2000

[4] DFO Fish Harvest Study (S. Stephenson, unpubl. data) for 1999

[5] DFO files, R. Peet, G. Low, unpublished data

[6] Thought to include commercial harvests in 1972, 1973 and 1975

Total annual harvests of Dolly Varden were estimated by summing 50% of the Inuvialuit catch at Shingle Point, the total caught in the Peel Channel at Aklavik by both Inuvialuit and Gwich'in fishers, and the totals caught at Husky Channel, Big Eddy, the mouth of the Rat River and at Destruction City (Fig. 2, Table 1). An unknown but probably small proportion of this harvest likely includes Dolly Varden from the Vittrekwa River and other Peel River tributaries (S. Stephenson, pers. comm.).

The average harvest of Rat River Dolly Varden was 3733 Dolly Varden per year for the three years of available data for the 1970's, 1890 for five years of data for the 1980's, and 1953 for ten years of data for the 1990's. Fishermen concur that harvest levels in the 1970's were higher than at present (J. Francis, J. Carmichael, pers. comms; GRRB 1997).

A small proportion of the subsistence harvest was sold commercially in 1972 and 1973. A commercial fishery with a quota of 900 kg was closed in 1985.

Resource User Perspective

The Gwich'in and Inuvialuit have long depended on the Rat River Dolly Varden for winter sustenance. These fish, called *Dhik'ii* by the Gwich'in (GRRB 1997) and *qalukpik* by the Inuvialuit (Lowe 1984), continue to be an important element of diet, tradition and culture to the present day. There are presently an estimated 190 head-of-household Gwich'in harvesters in Aklavik and Fort McPherson combined (B. Arey, pers. comm.) and of these, an average of 18 (9.4%) report regular annual harvests of Rat River Dolly Varden.

Forty years ago the majority of families from Fort McPherson went to the Rat River to fish (GRRB 1997). GRRB (1997:163) states:

> *"Char are important to people because they are considered a delicacy and a type of food that local people cannot get very often. Everybody likes the char because it is rich and tasty. In the old days, people would never joke about the char, or any other fish or animal because their survival depended on having a good relationship with them".*

"Long ago a medicine man used to live up the Rat River, near the Fish Hole. Even after he died, when in the fall families went to that place, parents told their children not to run around and be quiet because it was a sacred place".

Concerns of the harvesters about the status of the stock led to the development of a community-based fishing Plan, which has now been in place for six years (Aklavik RRC *et al.* 2000).

The goals of the Plan are to:

- maintain a healthy stock of char (Dolly Varden) in the Rat River system,
- maintain and manage the Rat River fishery for the continued use and enjoyment by the residents of Aklavik and Fort McPherson, and
- encourage co-operation among all users.

The Plan currently recommends that the total take of Dolly Varden in the food fishery not exceed 2000 per year, and specifies the number of nets that may be fished, their size and depth restrictions. Compliance with the Plan has been improving in recent years, with fishing in the 1999 and 2000 seasons being in full compliance with the recommendations of the Plan.

Resource Status

Stock Delineation

For Dolly Varden in North America, two subspecies are formally recognised: the southern taxon, *Salvelinus malma lordi*, and the northern taxon, *S. m. malma* (Behnke 1980). It is the northern subspecies that is present in the ISR and the Gwich'in Settlement Area. The two subspecies differ significantly with respect to their biology, productivity and related aspects of biology relevant to fishery management. Given these differences, the general transfer of understanding from the southern taxon, which is well studied, to the northern taxon, which is not, is problematic and must be conducted carefully if at all (Reist 2001).

The populations of the northern form of Dolly Varden that occur in Arctic Canada (Firth River, Joe Creek, Babbage River, Big Fish River, Rat River and Vittrekwa River) represent the only known populations of this distinct taxon in Canada. Thus, these fish are of interest as a unique part of the Canadian fish fauna (Reist 2001).

There appear to be at least six populations of the northern form of Dolly Varden in Canada. Studies using both morphology and genetic methods have confirmed the discreteness of fish from four river systems (Firth, Babbage, Big Fish and Rat). Data also indicate that fish from Joe Creek, a tributary of the Firth River, may be distinct from those that spawn in the Firth River (Reist 1989). Additional genetic information (i.e., sequence variation in mitochondrial DNA) confirms that these populations are all different from each other (J. Reist, unpubl. data) but mix along the coast during summer feeding and migrations.

Preliminary analysis of stock structure using otolith microchemistry for Firth River, Joe Creek and Babbage River confirms the structuring of Dolly Varden populations as determined by other methods (Babaluk *et al.* 1998; J. Babaluk unpubl. data).

Recapture of tagged fish support the genetic and microchemistry results, indicating that North Slope Dolly Varden stocks are discrete and show a high degree of fidelity to their natal spawning streams and over-wintering sites. Floy tags applied to Dolly Varden at the Rat River have only been recaptured approaching, or within, the Rat River system.

Dolly Varden tagged at the over-wintering site on the Big Fish River and at the Firth River have never been recaptured at, or approaching, the Rat River. Tagged fish from each of these sites have been caught during the summer coastal fishery at Shingle Point demonstrating that stocks do mix in the nearshore coastal environment. However, only small numbers of Dolly Varden tagged at the Rat River have been recaptured at the Shingle Point coastal fisheries (L. Harwood, unpubl. data).

Structuring within the Rat River Stock

Field observations in Fish Creek suggest that Dolly Varden of the Rat River may consist of two (or more) different spawning groups, although it is not known at this time if these groups represent genetic stocks. Spawning and spent sea-run Dolly Varden have been captured in Fish Creek in mid-August (S. Sandstrom, unpubl. data). A second group of Dolly Varden was observed spawning in a separate area of Fish Creek in mid-September (L. Harwood; S. Sandstrom, unpubl. data). Fishermen's observations of two or more pulses in the fishery (B. Mitchell, J. Carmichael, pers. comm.) also suggest there may be more than one group of Dolly Varden using the basin.

Preliminary genetic results also support this. Among anadromous Dolly Varden from the Rat, Babbage, Firth and Big Fish rivers, and Joe Creek, genetic diversity was highest in the Rat River samples (J. Reist, unpubl. data). These results also suggest that hidden structuring may be present in the Rat River stock(s), and is consistent with the suggestion of two or more temporally different spawning groups. Two distinct temporal groups of sea-run spawners, a summer and fall group, have been documented in some Alaskan systems (DeCicco 1989).

Stock Size

Several attempts have been made to estimate the number of sea-run Dolly Varden in the Rat River (Table 2). The first was in 1983 and involved a weir constructed upstream of Destruction City. An attempt was made to enumerate all migrants returning from the sea (Gillman and Sparling 1985). The weir was operational from August 8-30, 1983, during which time a total of 1312 upstream migrants were counted. Of this number, 57% were spawners. High water levels forced the removal of the weir while the run was in progress, and a complete count was not obtained.

Table 2. Mark-capture estimates of the size of the Rat River Dolly Varden stock(s)

Year	Est no	95% CI lower	95% CI upper	Method
1989[1]	10000[3]			Schaefer
1989[1]	11191	8532	15020	Petersen
1996[2]	9679	8194	11158	Petersen
1998[2]	14919	11265	18573	Petersen

[1] Stephenson and Lemieux (1990)
[2] L. Harwood, S. Sandstrom, unpublished data
[3] adjusted upwards by 1000 to account for fish taken in fishery
CI=confidence interval

In 1989, a mark-recapture estimate was conducted in the Destruction City area, using a hoop net to catch migrants returning from the sea, and the subsistence fishery at Destruction City as the recapture site (Stephenson and Lemieux 1990). A Petersen estimate was done one month later at the spawning and over-wintering site, using the tags put on downstream that summer and electro-shocking to recapture the fish (Table 2).

Petersen estimates were also conducted in 1996 and 1998 (Table 2). These involved capturing Dolly Varden at the over-wintering site using seine nets and marking with individually coded floy tags (n=355 in 1995; n=402 in 1997), and the subsistence fishery the following year as the recapture

mechanism (S. Sandstrom, L. Harwood, unpubl. data). The component of the harvest which would not have been vulnerable to tagging the previous fall was excluded from the calculations, and adjustments were made for tag loss and newly recruited fish.

Stock trend

Stock size estimates described above, although few in number, indicate no major change in the size of the stock in recent years. The 1998 estimate of stock size was higher than the 1989 and 1996 estimates, and this may represent an increase in the number of Dolly Varden using the system. Further mark-recapture studies are warranted to confirm the apparent trend.

Harvesters have observed an increase in the size of individual fish in recent years, and felt this was consistent with estimates of stock size which appear to be stable or possibly even increasing in number (J. Carmicheal, pers. comm.).

The CPUE (catch-per-unit-effort) in the 1995-2000 subsistence fishery remained relatively consistent with two exceptions (Table 3). The mean CPUE for 1998 was nearly twice the average for the 1995-2000 period, while at the other extreme the 2000 value was less than half the average for this period. It is believed these results are correlated with the timing of the runs in those particular years (Fig. 3). The run occurred three weeks earlier than usual in 1998, and three weeks later than usual in 2000. This in turn was thought to be related to the timing of break-up of the river ice, which was earlier than usual in 1998 and later than usual in 2000, and may explain the differences in CPUE and the timing of migration in those years (Harwood 2001).

Biological assessment surveys of Dolly Varden at the spawning and over-wintering site in Fish Creek in the fall of 1995 and

Table 3. Summary of sex, maturity and CPUE from the Rat River Dolly Varden subsistence fishery, 1989-2000

Year	% silvers	% males	Mean CPUE*	No. of fishers
1989	51.4	23.5	nd	nd
1990	71.9	37.9	nd	nd
1991	91.1	42.9	nd	nd
1992	nd	nd	nd	nd
1993	98.4	36.5	nd	nd
1994	93.5	30.3	nd	nd
1995	83.5	35.3	21.0	15
1996	68.7	33.1	30.6	14
1997	90.9	36.1	45.2	19
1998	83.9	40.6	74.0	18
1999	41.6	39.5	39.4	23
2000	68.8	37.8	18.6	19
Mean	76.7	35.8	38.1	18

nd = no data
*CPUE = no. of Dolly Varden/100 m net/24 hours

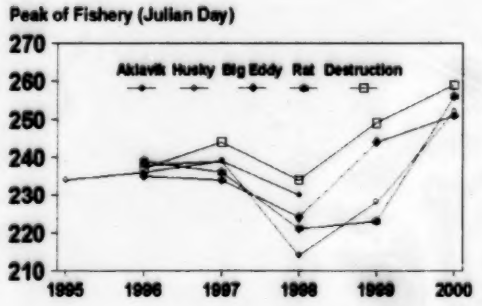

Fig. 3. Timing of the peak of the fishery for Rat River Dolly Varden, 1995-2000

1997 revealed that the mean size of individual fish did not change significantly during the intervening period for male spawners (Harwood 2001), female spawners or current year non-spawners (Fig. 4).

Subsistence harvest levels between the 1995 and 1997 studies were 1.5-1.7 times higher (n=2920, 1996; n=3393, 1997) than the average for the decade (n= 1953). The fact that size distribution of the fish between the two surveys remained relatively constant lends support to the conclusion that the harvest is sustainable.

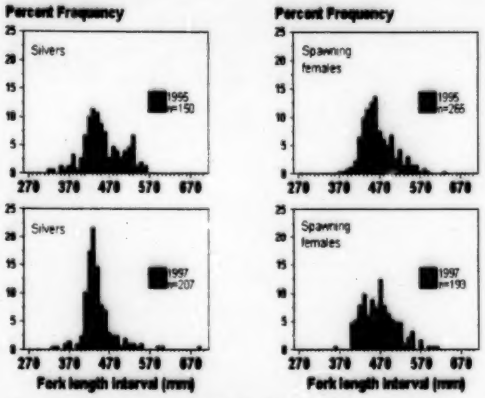

Fig. 4. Length-frequency distribution for current-year spawning females (right) and for current year non-spawners (left), captured by seine net at the spawning and overwintering site on Fish Creek, Rat River, 29 Sept. - 2 Oct. 1995 and 21-24 Sept. 1997.

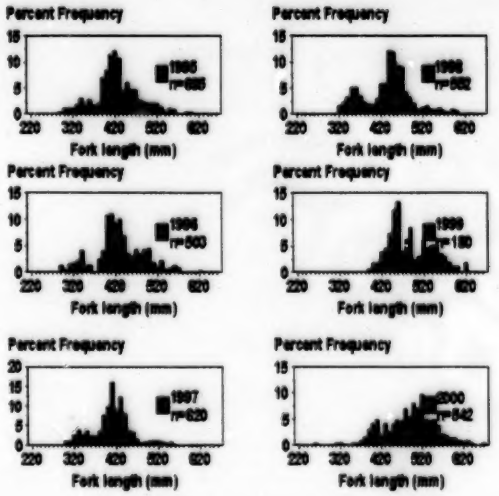

Fig. 5. Length-frequency distribution of current year non-spawning (silver) Dolly Varden caught in the fishery, 1995-2000

Sampling of the Dolly Varden harvests at Destruction City (1986-1994), and at four or five monitoring sites including Destruction City (1995-2000) (Fig. 2), provides a long-term record of size, sex, age and condition of Dolly Varden taken in the fishery (Harwood 2001). Current year non-spawners predominate the catch. Results from the harvest monitoring suggest the stock is stable, as a wide range of size classes were taken in the fishery each year and this did not appear to vary over time (Fig. 5; Harwood 2001). These results are consistent with the available historical data as well (Sparling and Stewart 1986).

One noticeable change in the distribution of size classes was the absence of smolts (approximately 320 mm fork length) in the harvest after 1998. This is likely due to the increase in mesh sizes used by the fishermen, associated with implementation of the Fishing Plan. An accurate estimate of the relative abundance of this component of the stock is important in interpreting trends and forecasting what will be available to the fishery the following year.

The average sizes of the male and female Dolly Varden taken in the fishery varied among years but there were no obvious trends toward increasing or decreasing length over time, up to and including 1998. In 1999 and 2000 the average length of both males and females was significantly greater than in the other 11 years examined (Harwood 2001). The apparent shift toward larger fish in 1999 and 2000 (Fig. 5) is likely the result of increased growth following optimal feeding opportunities in 1998.

Tagged Dolly Varden also showed high growth rates in 1998. Mean annual growth of 450-600 mm individuals, tagged in fall 1997, and recaptured in August 1998, was 75.9 mm (n=9). In contrast, the growth rate of 450-600 mm individuals tagged in fall 1995 and recaptured in late summer 1996 averaged 31.2 mm (n=32).

Silvers were caught more often than spawners in the fishery, and females outnumbered males (Table 3). The proportion of silver Dolly Varden caught in the fishery has averaged 76.7% between 1989 and 2000. The sex ratio of the catch has remained similar throughout the monitoring program. On average, 35.8% were males. This same bias toward females has been apparent in earlier studies at the

Rat River (Jessop *et al.* 1973, Gillman and Sparling 1985, Stephenson and Lemieux 1990).

There were no apparent shifts in the age structure of the Dolly Varden taken in the subsistence fishery. The average age of male and female Dolly Varden varied among years of the monitoring study, but there were no consistent trends toward increasing or decreasing mean age over time (Harwood 2001). Between 1995 and 2000, and as far back as 1986 (Sparling and Stewart 1986; Harwood 2001), the age-frequency distributions show a consistent and continued representation of the older age classes and no detectable changes in the shape of the distributions (Fig. 6).

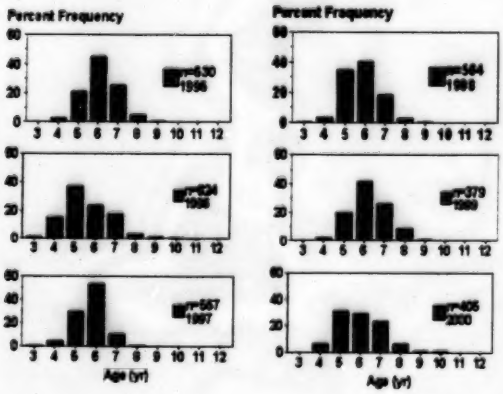

Fig. 6. Age-frequency distributions of Dolly Varden caught in the Rat River subsistence fishery, 1995-2000

While there was a decrease in the modal age class of one year between 1999 and 2000, this is likely due to a larger than average year class being recruited to the fishery because of unusually high growth rates in 1998. This will be monitored further in 2001 and beyond.

The instantaneous mortality rate (Z), calculated from the catch curve for Dolly Varden from the neighbouring (not harvested) Babbage River stock, was 0.28 (Sandstrom *et al.* 1997) for 1990-1992. In contrast, instantaneous mortality rates for the Rat River were higher, reflecting the combination of natural and fishing mortality at this system. Instantaneous mortality rates, calculated from the catch curves, were 0.57 in 1986 and 0.94 in 1989. Rates were even higher during the 1990's (Harwood 2001), with the most recent being 1.50 in 2000.

The condition of the Dolly Varden caught in the fishery was calculated using the equation: $K = \text{weight (g)} \times 10^5 / \text{length (mm)}^3$ (Anderson and Gutreuter 1983). Condition was significantly different among years with both male and female Dolly Varden having significantly higher K values in 1998 than in any of the other years examined (Harwood 2001; Fig. 7). In spring of 1998, regional ice conditions were light and ice break-up was earlier than usual. This appears to have resulted in particularly favourable or extended feeding conditions in the ocean that summer.

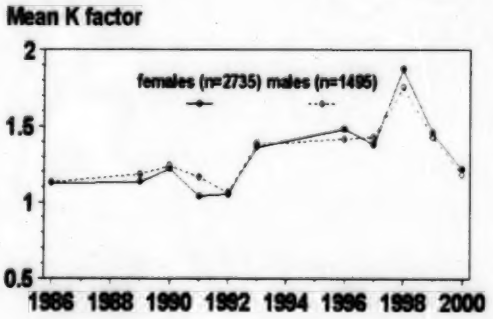

Fig. 7. Mean annual condition factor (K) for male and female Dolly Varden harvested in the Rat River subsistence fishery at Destruction City (1986-1994) and at the five monitoring sites including Destruction City (1995-2000)

In summary, a number of different indicators suggest that the Rat River Dolly Varden stock is stable and sustaining the present harvest level. Additional sampling of the juvenile sea-run components (smolts) would contribute further to our understanding of trends in the status of the stock.

Sustainable Harvesting Rate

The average annual harvest between 1990-1999 is equivalent to 13.0% of the 1998 estimate and 17.7% of the 1996 estimate. The present rate of harvest is probably lower than in the 1970's when the stock went into decline. Current indicators suggest that the present harvest is sustainable. There is no fishing at the spawning and over-wintering site at Fish Creek, a practice that further conserves the stock.

Sources of Uncertainty

CPUE may be indicative of changes in relative stock size, but at the same time is greatly influenced by changes in recruitment, migration patterns, local environmental conditions and/or changes in fishing practices. For these reasons, CPUE data must be interpreted with caution, and in combination with other lines of evidence.

Research and management initiatives to date have assumed that there is one stock of Dolly Varden in the Rat River. However, genetic and observational data suggest there may be more than one stock using the system. It has not yet been determined if early and late spawners are genetically distinct. Further, if there are other stocks present that are non-anadromous, their presence could bias information collected in the river.

Dolly Varden of the Vittrekwa River exhibit anadromy and thus likely migrate past the sites at which the Rat River Dolly Varden are fished (Fig. 1). The question remains as to the size of the Vittrekwa stock and it's contribution, if any, to the fishery. The Vittrekwa stock appears to be small, in comparison to the Rat River stock. Adult, juvenile and young-of-the-year Dolly Varden have been captured in the Vittrekwa during fall surveys, indicating spawning does take place within the basin (S. Stephenson, unpubl. data).

Fort McPherson residents also report the presence of Dolly Varden in the Road and Trail rivers, upstream of the Vittrekwa River (Fig. 1). Limited available information on these stocks suggests that, depending on the degree of anadromy, individuals from these stocks may be harvested during their migrations past Aklavik and along Husky Channel. If the Vittrekwa and other stocks contribute substantially to the Dolly Varden fisheries in the Mackenzie River delta, then estimates of the harvest from the Rat River stock are probably high.

The proportion (50%) of the catch at Shingle Point which is assigned to the Rat River stock is likely an overestimate, given the relatively few Rat River tag returns in the Shingle Point fishery. This overestimate is not likely to be consequential in terms of estimating the size of the harvest, however, as 50% of the harvest at Shingle Point is small, averaging only 120 per year (1990-1999, Table 1).

Biological data collected from fish harvested prior to establishment of the expanded and standardized monitoring program in 1995, are useful but must be interpreted with caution. Only one site was studied, in contrast to five sites in 1995-2000, and the monitor did not receive detailed instruction on assessing sex and maturity of the catch.

Harvest data from the 1970's may be incomplete, as sources and accuracy could not be evaluated.

Outlook

The outlook for the stock appears to be favourable, given further careful monitoring of the fishery and the harvest; periodic estimation of stock size; and compliance with the community-based and self-imposed

fishing restrictions. The timing of the run and condition of the fish vary considerably between years, and are closely tied to the environment.

Management Considerations

The Rat River Char Fishing Plan 2000 (Aklavik RRC *et al.* 2000) is the most important and specific management initiative in place at the present time for Rat River Dolly Varden and was endorsed by the RAP meeting participants. The Rat River Char Working Group consists of five fishers from each of the Aklavik RRC, the Fort McPherson RRC and the Aklavik HTC, two representatives from DFO, one member from the FJMC and one from the GRRB. The Group meets annually to update and ratify the fishing Plan for the year.

The upper reaches of the Rat River, which include the critical spawning and over-wintering sites for the Dolly Varden stock, are within the boundaries of the private lands of the Gwich'in established under the Gwich'in Final Agreement (Gwich'in and INAC 1992). The Gwich'in Land Administration is responsible for administration of these private lands.

The lower Mackenzie River and coastal waters used by Rat River Dolly Varden are located within the Inuvialuit Settlement Region (ISR; Fig. 1). The Environmental Impact Screening Committee and the Environmental Impact Review Board, established under the Inuvialuit Final Agreement (1984), are responsible for screening and review of any development activity on crown lands within the ISR that may have detrimental effects on the resources or their habitat.

Management of this fishery is complicated by not knowing the relative contribution of other stocks upstream of the Rat River (e.g., Vittrekwa, Road and Trail rivers).

Other Considerations

Infectious pancreatic necrosis virus is endemic in the Dolly Varden of the Rat River (Souter *et al.* 1984, 1986). This is a disease that only affects fish. Mortality of young fish is high and survivors can become lifelong carriers. The virus can be transferred from fish to fish by infected individuals excreting the virus into the water, and also through the eggs and sperm of infected adults to their offspring. Once the virus is present in a water system in the wild, eradication is impossible. The prevention of the introduction of diseased or carrier fish into non-infected watersheds remains the best control method for this and other fish pathogens. Periodic assessment of diseases in wild fish stocks, such as the Rat River Dolly Varden, is important to consider in the future (O. Nielsen, pers. comm.).

Other potential impacts such as contaminants and parasite loads on these fish have never been studied. Arctic lamprey and seals may be a significant source of mortality for juvenile sea-run Dolly Varden (primarily smolts) (S. Sandstrom, pers. comm.).

Habitat alteration and/or degradation of the spawning and over-wintering sites on Fish Creek are the major threats faced by this stock of Dolly Varden. Any development activity (e.g., roads, right-of-ways) which would diminish the integrity or physical characteristics (water level, oxygen level, silt loads, temperature, pH) of the spawning and over-wintering area, could pose a threat to developing embryos, rearing juveniles and/or spawning and over-wintering adults found in these areas. The integrity of the watershed must be maintained.

More pervasive threats, such as climate change and/or increased incident ultraviolet radiation resulting from ozone depletion, may affect the fish and their habitat, but the details of this are not understood at the present time.

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